

Statistical Approach to Optical Characterization of 3D Layered Photonic Crystals

A. Ponyavina, S. Kachan, N. Sil'vanovich

Institute of Atomic and Molecular Physics, National Academy of Sciences of Belarus,
70 F. Scorina Ave, 220072 Minsk, Belarus

Now it is well-known that periodicity of mesoscopic dielectric structures may create a situation when so called photonic prohibit zones appear. It is very attractive to use this effect for light transport controlling. However, today's technological difficulties usually give rise to some disturbance in a proper periodicity and monodispersity of 3D photonic crystals. Therefore there are many reasons to consider that practicable photonic crystal materials are not really an ideal periodical structure, but only a very high space ordered array of mesoscopic particles with some size distribution. The most effective theoretical approach for description of such media optical properties is the approach based on the statistical theory of multiple scattering of waves (STMSW).

Based on the STMSW, we have developed a numerical technique that allows to calculate coherent spectral transmission and reflection for three-dimensional (3D) layered photonic crystals consisted of monolayeres with a quasi-regular distribution of non-monodisperse dielectric spheres.

Multi-beam interference between monolayers was taken into account in the manner analogous to the transfer-matrix technique. Interference effects and electrodynamic coupling including near-field interaction between particles into a monolayer are considered in the quasicrystalline approximation as also was for 3D monodisperse layered photonic crystals [1,2]. Partial radial distribution functions for non-monodisperse close-packed monolayers were determined in the Percus-Yevick approximation from the solution of the generalized Ornstein-Zernike equation [3]. Single scattering properties are treated in the frame of the Mie theory.

We apply this technique to study the influence of particle size randomness on a bandgap spectral position and width, as well as on a short wavelength attenuation connected with incoherent scattering on particles of finite sizes.

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